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FOR:

METHOD AND SYSTEM FOR POWER-BASED CONTROL OF AN AD HOC WIRELESS COMMUNICATIONS NETWORK

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METHOD AND SYSTEM FOR POWER-BASED CONTROL OF AN AD HOC WIRELESS COMMUNICATIONS NETWORK

FIELD OF THE INVENTION

[0001]   The present invention relates to wireless communications. More particularly, the present invention relates to techniques for controlling selection of a coordinating device in a wireless ad hoc network.

BACKGROUND OF THE INVENTION

[0002]   Short range wireless systems typically involve devices that have a communications range of one hundred meters or less. To provide communications over long distances, these short range systems often interface with other networks. For example, short range networks may interface with cellular networks, wireline telecommunications networks, and the Internet.

[0003]   Wireless piconets, also referred to as personal area networks (PANs) typically operate in unlicensed portions of the radio spectrum, usually either in the 2.4 GHz Industrial, Scientific, and Medical (ISM) band or the 5 GHz Unlicensed-National Information Infrastructure (U-NII) band. Examples of wireless piconet technology include the Bluetooth standard and the IEEE 802.15.3 standard.

[0004]   Bluetooth defines a short-range radio network, originally intended as a cable replacement. It can be used to create ad hoc networks of up to eight devices, where one device is referred to as a master device. The other devices are referred to as slave devices. The slave devices can communicate with the master device and with each other via the master device. The Bluetooth Special Interest Group, Specification Of The Bluetooth System, Volumes 1 and 2, Core and Profiles: Version 1.1, February 22, 2001, describes the principles of Bluetooth device operation and communication protocols. Bluetooth devices operate in the 2.4 GHz radio band

reserved for general use by Industrial, Scientific, and Medical (ISM) applications. These devices are designed to find other Bluetooth devices within their communications range and to discover what services they offer.

[0005]   IEEE 802.15.3 defines a framework for devices to communicate at high data rates (e.g., 55 Mbps) at short ranges across ad hoc networks. Currently, an IEEE 802.15.3 piconet may support a large number of devices, such as 250. These devices share frequency channels by employing time division multiple access (TDMA) transmission and Carrier Sensing Multiple Access (CSMA) techniques. IEEE 802.15.3 piconets include a device known as a piconet controller or coordinator (PNC) and one or more other devices (referred to as DEVs).

[0006]   The PNC is a device that controls piconet resources. In particular, the PNC performs functions, such as controlling the basic timing for the piconet, and regulating the admission of devices into the piconet. In addition, the PNC manages quality of service (QoS) and security aspects of the piconet. To perform these functions, the PNC typically cannot enter an "idle" or "sleep" mode. Thus, the PNC consumes more power than the other devices in the piconet. Therefore, it is desirable to assign the PNC role to devices having a good battery condition, or even a fixed power supply.

[0007]   Multiple devices may join and leave the piconet during its existence. Likewise, different devices may assume the PNC role at various times. The process in which the PNC role is transferred between a first device and a second device is referred to herein as PNC handover. IEEE 802.15.3 provides for PNC handover through the use of a PNC handover command, which is issued for various reasons. However, these reasons do not currently include the status of a battery, but only information on the availability of a fixed power supply. In an ad hoc network, none of the devices may have a fixed power supply. The knowledge of battery levels in such a network could be used for balancing power consumption. The inability to determine the battery level in such a network may also cause a device with low battery power (that otherwise appears as a good PNC candidate) to be unable to reject the PNC role because of its low battery power, and run out of power after the PNC role is transferred to it. Accordingly, techniques are needed for taking available power source capacity of devices into consideration during PNC handover processes.

[0008]   In addition to the short-range networking techniques described above, ultra wideband (UWB) techniques have become an attractive solution for short-range wireless communications because they allow for devices to exchange information at relatively high data rates. Current FCC regulations permit UWB transmissions for communications purposes in the frequency band between 3.1 and 10.6 GHz. However, for such transmissions, the spectral density has to be under -41.3 dBm/MHz and the utilized bandwidth has to be higher than 500 MHz.

[0009]   There are many UWB transmission techniques that can fulfill these requirements. A common and practical UWB technique is called impulse radio (IR). In IR, data is transmitted by employing short baseband pulses that are separated in time by gaps. Thus, IR does not use a carrier signal. These gaps makes IR much more immune to multipath propagation problems than conventional continuous wave radios. RF gating is a particular type of IR in which the impulse is a gated RF pulse. This gated pulse is a sine wave masked in the time domain with a certain pulse shape.

[0010]   IR transmission facilitates a relatively simple transmitter design, which basically requires a pulse generator and an antenna. This design does not necessarily require a power amplifier, because transmission power requirements are low. In addition, this design does not generally require modulation components such as voltage controlled oscillators (VCOs) and mixers, because the impulses are baseband signals.

[0011]   In general, IR receiver designs are more complex than their corresponding transmitter designs. However, these designs are much simpler than conventional receiver designs because they typically do not employ intermediate frequency (IF) signals or filters. However, to fulfill spectral requirements, IR impulses have to be very short in duration (e.g., a couple of nanoseconds). This requirement places stringent timing demands on receiver timing accuracy. The fulfillment of these demands can also provide IR receivers with accurate time resolution and positioning capabilities.

SUMMARY OF THE INVENTION

[0012] A method, system and program code are provided to implement a wireless network having a plurality of devices in which one of the devices coordinates wireless communications between the devices. The method and system evaluates device parameters of one or more of the plurality of devices, the device parameters including at least available power source characteristics for a device; and determines a coordinator from the plurality of devices based on at least the available power source characteristics, such as an available power source capacity, for the one or more of the plurality of devices, the coordinator adapted to coordinate wireless communications between the devices in the wireless network.

[0013] The coordinator may be a piconet coordinator (PNC), and/or the devices may perform UWB, Bluetooth, IEEE 802.15.3 communications or communicate using other communication media and protocols.

[0014] The evaluation and determination operations may be implemented during formation of the wireless network, or after formation of the wireless network. The evaluation and determination operations may also be based on a triggering event, such as the occurrence when an available power source capacity of a current coordinator is less than a predetermined threshold, the occurrence when a current coordinator prepares for departure from the wireless network, the occurrence of a new device joining the wireless network.

[0015] A plurality of priorities may be stored, such as in a priority list. Each priority may have one or more corresponding device parameters. As part of the evaluation operation, each of the one or more devices may be assigned one of the priorities, where the assigned priority and the corresponding device have matching device parameters. As part of the determination operation, the coordinator is selected as a device from the one or more devices having the highest assigned priority.

[0016] The method, system and program code may further direct the determined coordinator to coordinate wireless communications between the devices in the wireless network.

[0017] Further features and advantages of the present invention will become apparent from the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018]　　In the drawings, like reference numbers generally indicate identical, functionally similar, and/or structurally similar elements. The drawing in which an element first appears is indicated by the leftmost digit(s) in the reference number. The present invention will be described with reference to the accompanying drawings, wherein:

[0019]　　FIG. 1 is a diagram of an exemplary operational network environment;

[0020]　　FIG. 2 is a block diagram of an exemplary communications device architecture;

[0021]　　FIG. 3 is a block diagram of an exemplary communications device implementation;

[0022]　　FIG. 4 is a block diagram of an exemplary device architecture in accordance with an embodiment.

[0023]　　FIG. 5 is an exemplary IEEE 802.15.3 High Rate (HR) frame format in accordance with an embodiment;

[0024]　　FIG. 6 is an exemplary IEEE 802.15.3 High Rate (HR) capability field format in accordance with an embodiment;

[0025]　　FIG. 7 is an exemplary IEEE 802.15.3 High Rate (HR) priority list in accordance with an embodiment;

[0026]　　FIG. 8 is an exemplary IEEE 802.15.3 High Rate (HR) priority list with power source status indication (PSSI) support in accordance with an embodiment; and

[0027]　　FIGs. 9 and 10 are flowcharts of exemplary coordinator selection processes.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

I.　　Operational Environment

[0028]　　Before describing the invention in detail, it is helpful to describe an environment in which the invention may be used. Accordingly, FIG. 1 is a diagram of an operational environment 100 that includes a parent piconet 106 and a child piconet 110. In embodiments,

piconets 106 and 110 may operate according to various standards, such as IEEE 802.15.3 and Bluetooth.

[0029]   Piconet 106 includes a coordinator device 102 and a plurality of devices 104. Coordinator device 102 controls the resources of piconet 106. For example, coordinator 102 controls the basic timing of piconet 106 and regulates the admission of devices into piconet 106. In addition, coordinator 102 may manage various quality of service (QoS) and security aspects of the piconet. In embodiments employing IEEE 802.15.3, coordinator device 102 may be a piconet coordinator (PNC). In embodiments employing Bluetooth, coordinator device 102 may be a master device.

[0030]   The devices of piconet 106 exchange information through the transmission of wireless signals. These signals may be, for example, carrier-based or ultra wideband (UWB) signals. Various multiple access techniques may be employed so that the devices of piconet 106 may share allocated portions of a wireless communications media (e.g., a frequency range in the RF communications spectrum). Exemplary multiple access techniques include time division multiple access (TDMA), time division duplex (TDD), frequency division multiple access (FDMA), and code division multiple access (CDMA).

[0031]   For instance, in embodiments involving IEEE 802.15.3, the devices of piconet 106 communicate according to a TDMA frame structure that includes a beacon period, a contention access period, and a contention free period. Embodiments employing Bluetooth employ a TDD frame format. This TDD format includes alternating slots in which master and slave devices communicate according to a polling scheme.

[0032]   Child piconet 110 may operate with a portion of bandwidth allocated from parent piconet 106, such as a TDMA time slot of the parent piconet 106. As shown in FIG. 1, child piconet 110 includes a coordinator device 108, which performs functions similar to the functions performed by coordinator device 102.

[0033]   FIG. 1 illustrates a configuration of piconets 106 and 110 at a given point in time. However, the characteristics of these networks may change over time. For instance, during operation, the membership of piconet 106 may change through the departure and arrival of different devices. In addition, the coordinator role may be transferred from device 102 to

another device in piconet 106 according to a coordinator handover operation. Such coordinator handovers may be performed in accordance with power-based techniques of the present invention.

[0034]   For example, in one aspect of the method and system herein, the devices exchange device parameters. This information may be exchanged during initial formation of the wireless network or after establishment thereof. The device parameters may include a power source status indicator of a device indicating the available power source capacity for the device. The initial coordinator or subsequent coordinators to which control is handed off may be determined according to the power source status indicator of one or more devices in the wireless network.

II.   Wireless Communications Device

[0035]   FIG. 2 is a block diagram showing a wireless communications device architecture, which may be used for devices 102, 104 and 108. Although this architecture is described in the context of Bluetooth and UWB communications, it may be employed with other wireless communications technologies.

[0036]   The device architecture of FIG. 2 includes a host 202, which is coupled to a Bluetooth segment 210, and a UWB segment 220. Host 202 is responsible for functions involving user applications and higher protocol layers, while Bluetooth segment 210 and UWB segment 220 are responsible for lower layer protocols. More particularly, Bluetooth segment 210 is responsible for Bluetooth specific communications with other devices, and UWB segment 220 is responsible for UWB specific communications with other devices.

[0037]   As shown in FIG. 2, Bluetooth segment 210 includes a host controller interface (HCI) 212, a Bluetooth module 214 with a link manager and a link controller, a Bluetooth transceiver 216, and an antenna 218.

[0038]   The link manager performs functions related to Bluetooth link set-up, security and control. These functions involve discovering corresponding link managers at remote devices and communicating with them according to a link manager protocol (LMP). To perform these

functions, LMP defines a set of messages, which are also referred to as protocol data units (PDUs). The Link manager exchanges these PDUs with link managers at remote devices.

[0039] The link manager exchanges information with host 202 across HCI 212. This information may include commands received from host 202, and information transmitted to host 202. HCI 212 defines a set of messages, which provide for this exchange of information.

[0040] The link controller operates as an intermediary between the link manager and Bluetooth transceiver 216. The link controller also performs baseband processing for Bluetooth transmission, such as error correction encoding and decoding. In addition, the link controller exchanges data between corresponding link controllers at remote devices according to physical layer protocols. Examples of such physical layer protocols include retransmission protocols such as the automatic repeat request (ARQ) protocol.

[0041] FIG. 2 shows that Bluetooth transceiver 216 is coupled to an antenna 218. Transceiver 216 includes electronics that allow the device of FIG. 2 (in conjunction with antenna 218) to exchange wireless Bluetooth signals with devices, such as a remote device 104. Such electronics include modulators and demodulators, amplifiers, and filters.

[0042] When the device of FIG. 2 engages in UWB communications, it employs the services of UWB segment 220. As shown in FIG. 2, UWB segment 220 includes an interface 222, a UWB module 224, a UWB transceiver 226, and an antenna 228. Interface 222 provides for communications between host 202 and UWB module 224.

[0043] UWB module 224 provides for the exchange of information across UWB links according to one or more protocol layers. For example, UWB module may provide session management functionality to manage various UWB sessions. In addition, UWB module 224 may perform baseband processing, such as error correction encoding and decoding. In addition, UWB module 224 perform various link level protocols with remote devices according to physical layer protocols. Examples of such protocols include retransmission protocols such as the automatic repeat request (ARQ) protocol.

[0044] In an aspect of the method and system herein, UWB module 224 may implement the IEEE 802.15.3 High Rate (HR) framework to perform communications in an ad hoc wireless

communications network environment. A more detailed discussion of an exemplary implementation employing the IEEE 802.15.3 framework is provided below with reference to FIGs. 4 through 8.

[0045]   UWB transceiver 226 is coupled to antenna 228. UWB transceiver 226 includes electronics, which allow the device of FIG. 2 (in conjunction with antenna 228) to exchange wireless UWB signals with devices, such as remote devices 104 and 108. For the transmission of UWB signals, such electronics may include a pulse generator. For the reception of UWB signals, such electronics may include timing circuitry and filters.

[0046]   The architecture of FIG. 2 may be implemented in hardware, software, firmware, or any combination thereof. One such implementation is shown in FIG. 3. This implementation includes a processor 310, a memory 320, and an interface 340 such as an interface to other devices or a user. In addition, the implementation of FIG. 3 includes transceivers 350 and antennas 352. Transceivers 350 may include a Bluetooth transceiver (e.g., 216) and UWB transceiver (e.g., 226) such as described above with reference to FIG. 2 or other suitable types of transceivers which support ad hoc wireless networking.

[0047]   As shown in FIG. 3, processor 310 is coupled to transceivers 350. Processor 310 controls device operation. Processor 310 may be implemented with one or more microprocessors that are each capable of executing software instructions stored in memory 320.

[0048]   Memory 320 includes random access memory (RAM), read only memory (ROM), and/or flash memory, and stores information in the form of data and software components (also referred to herein as modules). These software components include instructions that can be executed by processor 310. Various types of software components may be stored in memory 320. For instance, memory 320 may store software components that control the operations of transceivers 350. Also, memory 320 may store software components that provide for the functionality of host 202, interface 212, BT module 214 (e.g., link manager, link controller, etc.), interface 22, UWB Module (e.g., Media Access Control (MAC), PHY, etc.).

[0049]   In addition, memory 320 may store software components that control the exchange of information through interface 340. As shown in FIG. 3, user interface 340 is also coupled to processor 310. Interface 340 facilitates the exchange of information with a user or

other device or component. FIG. 3 shows that interface 340 includes an input portion 342 and an output portion 344. Input portion 342 may include one or more devices that allow a user or other devices to input information. Examples of such devices include keypads, touch screens and microphones, and data communications interfaces such as serial port, parallel port, 1394 interface, USB interface, and so forth. Output portion 344 allows a user or other device to receive information from the wireless communications device. Thus, output portion 344 may include various devices, such as a display, and one or more audio speakers, and data communications interfaces such as serial port, parallel port, 1394 interface, USB interface, and so forth. Exemplary displays include liquid crystal displays (LCDs), and video displays.

[0050] The elements shown in FIG. 3 may be coupled according to various techniques. One such technique involves coupling transceivers 350, processor 310, memory 320, and interface 340 through one or more bus interfaces.

[0051] In addition, each of these components is coupled to a power source facility 330 which includes a power manager 332, fixed power source interface 334 such as an AC/DC interface for connecting to a fixed power supply, and a battery 336 such as a removable and rechargeable battery pack. Power manager 332 or the like may be employed to manage power usage in the wireless communications device. Such management may include detection and maintenance of information on power source availability or power source status for the device, and selective control of power source for device functions and components. Power manager 332 may be configured as part of the device's operating system or a separate module or so forth, as desired.

III.   Exemplary IEEE 802.15.3 Piconet Implementation

[0052] FIG. 4 is a diagram of an exemplary device architecture 400. This architecture allows devices to employ various wireless communications frameworks (such as IEEE 802.15.3) according to embodiments of the present invention. Device architecture 400 provides for communications with other devices according to a multi-layered protocol stack. As shown in FIG. 4, this protocol stack includes a physical layer 410, a data link layer 420, and a convergence layer 430.

[0053]   Physical layer 410 includes a physical (PHY) sub-layer 412. PHY sub-layer 412 is responsible for transmitting and receiving signals with a wireless medium. These signals may be RF signals (carrier-based and/or UWB) as well as optical signals. In addition, PHY sub-layer 412 receives data for transmission from data link layer 420 and sends it to data link layer 420 symbols (e.g., bit streams) corresponding to wireless signals received from the wireless medium.

[0054]   Data link layer 420 includes a media access control (MAC) sub-layer 422. MAC sub-layer performs functions involving formatting of data for transmission, synchronization of transmissions, flow control, and error detection/correction. As shown in FIG. 4, MAC sub-layer 422 communicates with PHY sub-layer 412 via a PHY service access point (SAP) interface.

[0055]   A convergence layer 430 includes one or more convergence sub-layers 432. Sub-layers 432 provide for higher layer functions, such as applications. Such applications include (but are not limited to) audio, video, high speed data access, voice (e.g., telephony), IP, USB, 1394 and so forth.

[0056]   FIG. 4 shows that MAC sub-layer exchanges information with a MAC layer management entity (MLME) 424 and PHY sub-layer 412 exchanges information with a PHY layer management entity (PLME) 414.

[0057]   MLME 424 and PLME 414 provide for basic signaling functions to be performed between piconet devices so that connections may be set-up, managed, and released. In addition, these signaling functions may exchange information that facilitate the coordinator handover techniques of the present invention. Such information includes various device status information, as well as commands or messages for directing a coordinator handover according to the techniques of the present invention.

[0058]   As shown in FIG. 4, MLME 424 and PLME 414 are coupled to a device management entity (DME) 440 by corresponding service access point (SAP) interfaces. DME 440 directs various fuctions of MLME 424 and PLME 414 involving, for example, resource allocation decisions.

[0059]   FIG. 5 is a diagram of an exemplary IEEE 802.15.3 TDMA frame format. This frame format includes a repeating pattern of superframes. This frame format may be employed in networks employing the techniques of the present invention.

[0060]   As shown in FIG. 5, each superframe includes a beacon period, a contention access period, and a contention free period. The beacon period is used to convey control information from the coordinator to the entire piconet. Examples of such control information involves, for example, synchronization, transmit power level constraints, and the allocation of time slots to devices in the piconet. The contention access period is used for devices to transmit information to the piconet coordinator. Such information includes authentication requests and channel time requests. Transmissions during the contention access period may employ a protocol, such as slotted Aloha, which has been proposed for the enhanced 802.15.3 MAC for UWB. The contention free period includes management time slots (MTS) and guaranteed time slots (GTS), which are used for isochronous streams and asynchronous data connections.

[0061]   FIG. 6 is an exemplary capability field format 600 identifying various capability attributes or characteristics of a device for implementing the IEEE 802.15.3 framework. Format 600 may include a PNC Capable field identifying whether the device is capable of being a coordinator; a Supported Data Rates field identifying the data rates supportable by a device; an Asynchronous Data Support field identifying whether the device supports asynchronous data communications; and a Neighbor PNC field identifying the neighboring PNC such as by its piconet address (PNID) or other identifier. Format 600 may further include Power Save Mode field (PSAVE) identifying whether the device supports power saving modes; a Power Source (PSRC) field identifying the type of Power Source (e.g., Fixed or Battery) employed by the device; a Security (SEC) field identifying whether the device supports security features such as encryption; and PNC Designated Mode (Des Mode) identifying the device's desirability to operate in PNC designated mode.

[0062]   In accordance with an aspect of the method and system herein, format 600 may further include a Power Source Status Indicator (PSSI) for indicating available power source or power source status of the device. The power source statuses may include, for example, a fixed

power supply, a full or almost full battery, half battery and nearly depleted battery. These may be reflected in the following priority:

1   -   Fixed Power Supply Condition

2   -   Full Battery Condition (and/or Almost Full Battery Condition)

3   -   Half Battery Condition

4   -   Empty Battery Condition (and/or Almost Empty Battery Condition).

The above is simply an example of power source conditions and status information. Other conditions, either even more specific (e.g., percentage level, etc.) or general (e.g., Good Power Source Condition and Bad Power Source Condition), may be maintained and transmitted to other devices to facilitate determination of an initial or subsequent coordinator(s) of the wireless network. It may, however, be desirable to reduce the categories of conditions and employ general or broad categor(ies) of condition definitions since devices may have different power capacities and power consumption is difficult to forecast exactly.

[0063]   Another way of introducing the condition of power source is to enhance the PSRC bit with one or more bits. For instance, modifying the PRSC to have two more bits allows for enable determination of power source condition, such as with the PSSI as described above, and would eliminate the need for a separate field(s) such as the PSSI. An example of the represented conditions using two bits may be as follows:

1 (11) -   Fixed Power Supply Condition

2 (10) -   Full Battery Condition (and/or Almost Full Battery Condition)

3 (01) -   Half Battery Condition

4 (00) -   Empty Battery Condition (and/or Almost Empty Battery Condition).

The power source capacity level could be determined in PHY/MAC layer or set by higher layers depending on implementation.

[0064]   Format 600 may also include one or more Reserved fields for maintaining and identifying other device capabilities to facilitate network communications.

[0065]   FIG. 6 is simply one example of a capability field format. The various field orders, field types and field lengths (e.g., bit(s)) may be configured to facilitate communications and the method and system herein. For example, the capability field format may include more or less field types and the field lengths may be increased and decreased. Although the power source status indicator may be maintained, as part of device capability information, such information may be maintained or provided in other formats or with other information to implement the method and system herein. The coordinator may request, maintain and update the capability information of all devices.

[0066]   FIG. 7 is an exemplary IEEE 802.15.3 priority list which may be employed in the determination of a coordinator according to various device attributes or characteristics. As shown in FIG. 7, various device characteristics have been prioritized to assist when comparing devices to determine or select which device should be the coordinator.

[0067]   In this example, eight device attributes may be examined in the following priority order (from highest to lowest): (1) PNC Designated Mode (Des Mode), (2) Security (SEC), (3) Power Source (PSRC), (4) Power Save Modes (PSAVE), (5) Maximum Number of Available Guaranteed Time Slots (GTS), (6) Transmitter Power Level, (7) Maximum PHY Rate and (8) Device Address (e.g., Piconet Address).

[0068]   PNC Des Mode identifies whether the device's current designated mode is PNC. A PNC Des Mode bit equal to one (which reflects a desire to be a PNC) is preferred.

[0069]   SEC identifies whether the device supports security features, such as encryption. A SEC bit equal to one (which acknowledges support for security) is preferred.

[0070]   PSRC identifies the type of power source such as a fixed or battery power source. A PRSC bit equal to one (which identifies a fixed power source) is preferred.

[0071]   PSAVE identifies whether the device supports power saving modes. A PSAVE bit equal to one (which acknowledges support for power saving modes) is preferred.

[0072]   The transmitter power level, Maximum PHY Rate and Device address are self explanatory. Higher values for these attributes are preferred.

[0073]   The priority list or the like may be employed by a PNC or DEVs to determine the desirability of a device as a candidate for coordinator. The coordinator selection processes may take place during formation of a piconet to ascertain which device should take on the role of coordinator, or may take place after formation of a piconet when the PNC desires to handover its role as a coordinator, or when another DEV challenges the PNC for the coordinator role, or upon other events or factors.

[0074]   FIG. 8 is an exemplary IEEE 802.15.3 priority list with power source status indicator (PSSI) support. The priority list of FIG. 8 is substantially the same as FIG. 7 discussed above, except for the addition of a power source status indicator (PSSI) device attribute with a priority level of four. The PSSI identifies available power or power source status of a device. The preferred PSSI is one reflecting higher power capacity such as fixed power supply source or full battery condition, as discussed above with reference to FIG. 6.

[0075]   It may be desirable to have the PSSI at a relatively high priority level on the priority list, particularly from the prospective of battery operated devices. In this way, an approach is provided to address the possibility of handing over or giving the coordinator role to a device with low battery. Although FIG. 8 shows PSSI attribute with a priority level of four, the PSSI or the like may be assigned a higher or lower priority level on the priority list depending on various factors such as the application environment (e.g., game playing, transferring files, etc.), etc.

[0076]   Although the above discusses an example of a priority list implementation, other approaches and formats may be employed to determine or select a coordinator according to power source status of at least one of the devices of the wireless network. Instead of a priority list, coordinator selection may be based on a weighted average of the attributes of a device as compared to other devices or a threshold, and so forth. Each priority level may also have one or more corresponding device parameters (e.g., priority level "x" is associated with PSSI below two and PSAVE equal one, etc.).

[0077]   Although FIGs. 4 through 8 discuss a UWB implementation using the IEEE 802.15.3 framework, other frameworks such as Bluetooth may be employed in the method and system herein.

IV.   Device Interactions

[0078]   FIG. 9 is a flowchart of an exemplary coordinator selection process 900 which may take place during the formation of a wireless network, such as shown in FIG. 1, including a plurality of devices (e.g., 102 and 104) with one device being designated as the coordinator (e.g., 102). The network may be a Bluetooth piconet, or a UWB piconet implementing the IEEE 802.15.3 framework.

[0079]   At step 902, wireless communication devices (DEVs) begin negotiations to form a wireless network, such as an ad hoc wireless network. This may be initiated by one device discovering the presence of another device. The devices exchange messages to set up communications therebetween. These messages may include device parameters, such as the device attributes discussed above with reference to FIGs. 7 and 8.

[0080]   At steps 904 and 906, a coordinator selection procedure may be initiated and device parameters are evaluated for at least one of the devices, respectively. The device parameters include at least a power source status indicator indicating available power or power source status of a device. At step 908, a device is determined or selected as a suitable candidate for coordinator based on at least the power source status indicator of at least one of the devices.

[0081]   The steps 906 and 908 may be performed, for example, employing priority lists described above with reference to FIGs. 7 and 8. These priorities of device parameters may be stored, retrieved or accessed, as desired. One or more or all of the devices may be assigned a priority depending on the device(s)' parameters, such as a device's parameter(s) matching an appropriate priority category on the priority list. A coordinator candidate device may then be selected from the one or more devices having the highest assigned priority.

[0082]   In one example, the evaluation and determination steps may involve the devices transmitting or broadcasting their parameters or priorities. The devices compare their own parameters or priority versus the parameters or priority of the other devices. As comparisons are made, those devices with less desirable parameters or priority stop transmitting or broadcasting.

The remaining transmitting or broadcasting device is determined to be a suitable coordinator candidate or winner.

[0083] At step 910, wireless network operations are established with the determined device as the coordinator, and communications may then proceed between the devices. The coordinator may act as a conduit to route communications between devices and/or facilitate establishment of peer-to-peer communications directly between devices.

[0084] FIG. 10 is a flowchart of an exemplary coordinator selection process 1000 which may take place after formation of a wireless network, such as shown in FIG. 1, including a plurality of devices (e.g., 102 and 104) with one device being designated as the coordinator (e.g., 102). The network may be a Bluetooth piconet, or a UWB piconet implementing the IEEE 802.15.3 framework.

[0085] At step 1002, the coordinator initiates a coordinator selection procedure. This procedure may be initiated based on various events or factors, which may include the following:

(1) A new device seeks entry or is added to the wireless network (e.g., such as a new device with improved power source status);

(2) A device or the coordinator seeks to leave or leaves the wireless network (e.g., the available power of the coordinator is less than a predetermined threshold or the coordinator is moving out of range);

(3) The device parameters of one or more of the devices in the wireless network changes (e.g., a device becomes coupled to a fixed power supply);

(4) A triggering event occurs at the coordinator (e.g., user defined thresholds, such as power thresholds or other factors or circumstances, are met);

(5) Another device challenges the coordinator for the coordinator position; and

(6) User of the coordinator device initiates the procedure.

[0086] The above are simply a few examples of events or factors which may cause the initiation of the coordinator selection procedure. Other events and factors may also initiate the procedure, as desired.

[0087] At step 1004, the coordinator evaluates the device parameters for at least one of the devices. The device parameters include at least a power source status indicator indicating

available power or power source status of a device. At step 1006, the coordinator determines or selects a device as a suitable candidate for the coordinator position based on at least the power source status indicator of at least one of the devices.

[0088]   The steps 1004 and 1006 be performed, for example, employing priority lists described above with reference to FIGs. 7 and 8. These priorities of device parameters may be stored, retrieved or accessed, as desired. One or more or all of the devices may be assigned a priority depending on the device(s)' parameters, such as a device's parameter(s) matching an appropriate priority category on the priority list. A coordinator candidate device may then be selected from the one or more devices having the highest assigned priority.

[0089]   At step 1008, the coordinator hands over the coordinator position to the determined device or candidate. This may involve exchanging messages between the two devices. For example, the coordinator may direct the candidate to coordinate wireless communications between the devices, with a request to hand over coordinator position from the coordinator and the candidate may respond by accepting such a request. The coordinator may also send to the candidate information of the devices in the wireless network and/or other information necessary to implement the coordinator duties. Other devices are also informed of the change in responsibilities.

[0090]   Thereafter, the coordinator relinquishes its duties as the coordinator, and the candidate obtains control as the new coordinator.

V.   Conclusion

[0091]   While various embodiments of the present invention have been described above, it should be understood that they have been presented by way of example only, and not in limitation. For instance, although examples have been described involving Bluetooth and UWB and WPAN technologies, other short-range and longer range communications technologies and wireless networks, such as Wireless Local Area Network (WLAN), are within the scope of the present invention.

[0092] Accordingly, it will be apparent to persons skilled in the relevant art that various changes in form and detail can be made therein without departing from the spirit and scope of the invention. Thus, the breadth and scope of the present invention should not be limited by any of the above-described exemplary embodiments, but should be defined only in accordance with the following claims and their equivalents.